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ABSTRACT

This executive summary reports the findings of a study of the mathematics participation and performance of female, Black, and Hispanic students in the Montgomery County Public Schools (Maryland), and generalizes its findings to mathematics instruction for all students. Goals of the study were the following: (1) identify at what point in the educational process differences first appear; (2) identify factors in the school, home, and society that contribute to differential mathematics participation; and (3) point out policy implications and suggest alternatives or solutions. The sources of statistical and attitudinal data, and the methods used to select the sample populations are outlined in a fact sheet. Major summary findings include the following: (1) gender differences in participation and performance do not emerge until the last year or two of high school, but differences in attitudes and beliefs about mathematics start much earlier; (2) differences in progress through the elementary mathematics curriculum between Blacks and Hispanics, and Asians and Whites emerge as early as the first and second grade; (3) large differences exist in participation and performance in the secondary mathematics curriculum between Blacks and Hispanics, and Asians and Whites; and (4) the best way for any student to be successful in mathematics is to have succeeded in mathematics in the past, but once a student experiences failure or falls behind grade level, it is more difficult to catch up. Statistical data are included on four tables and three graphs. (FMW)

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**MONTGOMERY COUNTY
PUBLIC SCHOOLS
ROCKVILLE, MARYLAND**

**Participation and Performance of
Women and Minorities
in Mathematics**

**A Project Supported by National Science Foundation
Grant No: MDR-8470384 and the
Montgomery County Public Schools**

July 1988

EXECUTIVE SUMMARY

**Harry Pitt
Superintendent of Schools**

Prepared by the Department of Educational Accountability

MONTGOMERY COUNTY PUBLIC SCHOOLS
Carver Educational Services Center
Rockville, Maryland

PARTICIPATION AND PERFORMANCE OF WOMEN AND MINORITIES IN MATHEMATICS:

A PROJECT SUPPORTED BY NATIONAL SCIENCE FOUNDATION GRANT NO. MDR-8470384
AND THE MONTGOMERY COUNTY PUBLIC SCHOOLS

EXECUTIVE SUMMARY

By

Dr. Susan Gross

The opinions expressed in this report are those of Montgomery County Public Schools, and do not necessarily reflect those of the National Science Foundation.

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PARTICIPATION AND PERFORMANCE OF WOMEN AND MINORITIES
IN MATHEMATICS

EXECUTIVE SUMMARY

BACKGROUND

For more than a decade, Montgomery County Public Schools (MCPS) has had priority goals for the education of female, Black, and Hispanic students in key academic areas such as mathematics. The school system has devoted a great deal of time, attention, and resources to the development of innovative curricula, staff awareness and sensitivity to cultural differences and sex role stereotypes, and staff training in promising practices and strategies such as differentiated instruction. The following are some of the major steps that have been taken:

- o MCPS led the nation in establishing a Board of Education policy in 1972 that mandated specific actions on the part of staff to address the problem of underachievement and underrepresentation of Black students in academic and extracurricular areas.
- o In the mid 1970's, MCPS conducted an institutional study required by Title IX, and designated a Title IX Coordinator in the Department of Human Relations. Annual conferences have been conducted by the Department of Human Relations and the Office of Instruction and Program Development, to provide staff with ways of fostering interest of female, Black, and Hispanic students in technical courses and careers.
- o The school system was the first in the greater Washington D.C. area to publish standardized test score results in 1978, showing differential performance by gender and racial/ethnic group.
- o Commitment to increasing Black and Hispanic students' achievement and participation was reiterated in 1983 when the Board of Education set the priority to:¹ "implement a special emphasis program that will result in substantial gains in a) the performance of minority students in the classroom and on standardized and criterion-referenced tests; b) the participation of minority students in programs for the gifted and talented, higher level academic courses, and extracurricular activities."
- o In 1985 MCPS adopted a policy on Women's Equity which stipulated actions that school and central office personnel must take to ensure equal opportunity and elimination of sex role stereotypes concerning student participation in courses, athletics, and other extracurricular activities, as well as staff employment opportunities.
- o In 1985 the MCPS Board of Education adopted the Initiatives for Sex Equity, which had several long-range goals: improvement of SAT scores for females, increased enrollment of females in computer science

1. PRIORITIES: Montgomery County Board of Education, Montgomery County Public Schools, September 1983.

courses and advanced courses in mathematics and science, and increased participation of women in nontraditional careers.

Such self-examination and leadership is essential to a vital school system.

In the last 10-12 years, substantial progress has been made toward these goals. For example, today, the performance of female, Black, and Hispanic students in the County far exceeds national levels of achievement for these groups. Within the state of Maryland as well, females, Blacks, and Hispanics outperform their peers in the other local school systems. This contrasts sharply with conditions in 1978 when Black students at all grade levels and Hispanic students in grades 7, 9, and 11 scored below national norms in mathematics achievement.

Despite these gains, the performance of female, Black, and Hispanic students continues to be a major concern. MCPS's proposal to the National Science Foundation (NSF) for funds to conduct a study of the participation and performance of female and minority students in mathematics is just one indicator of the continued interest in these areas. The unprecedented award by NSF to a school system rather than to an institution of higher education reflects NSF's judgment that MCPS is on the cutting edge of research, curriculum development, and student data management in these areas.

This document contains the findings of the NSF-funded study. The data show that, in many areas, MCPS has made great strides toward meeting the needs of its students in mathematics instruction. However, while the mathematics performance and participation of MCPS's female, Black, and Hispanic students has shown substantial improvement over the last decade, differences are still observed for students in different gender and racial/ethnic groups. This study represents one more step in MCPS's initiative in meeting the complex needs of all students in mathematics. Based on the findings in Montgomery County, it is likely that gender and racial/ethnic group performance and participation differences must be far greater in school systems that have not devoted similar time, attention, and resources to these issues.

Study Focus and Objectives

Over the last ten years or so, investigators have attempted to identify the factors that influence participation and success in mathematics for female, Black, and Hispanic students. In general, the research literature suggests that gender differences in mathematics participation do not emerge until senior high school, where mathematics course enrollment becomes optional after the completion of one or two years of required course-work. Females are less likely than males to enroll in elective and advanced mathematics courses and are less likely to pursue careers or fields of study that require heavy concentrations in mathematics. What few studies do address the mathematics experiences of minority students report large discrepancies in the performance of Black and Hispanic students when compared to White and Asian students at the elementary school level. These discrepancies continue to expand through the high school years.

This study of female, Black, and Hispanic students' mathematics participation and performance explored those factors which were believed to contri-

bute to differential course-taking histories within the context of the elementary, junior high/middle, and high school environments. It was assumed that many of the decisions students make concerning high school mathematics participation have their roots in the elementary years. Thus, while a major focus of this study was the junior/high middle school and high school mathematics participation and performance of female, Black, and Hispanic students, the study also examined the mathematics participation² and performance of these groups of students in elementary school. Particular attention was devoted to those factors that might help explain the differential participation and performance of females compared to males, and Black and Hispanic male and female students compared to Asian and White males and females.

The overall goals of the study were threefold:

- o to identify at what points, if any, in the educational process differences appear in the mathematics participation and performance of females compared to males, and Blacks and Hispanics compared to Asians and Whites, and to describe these differences
- o to identify the factors in the school, home, and society that contribute to the differential mathematics participation of female, Black, and Hispanic students at the elementary, junior high/middle and senior high school levels
- o to provide, where possible, the policy implications of the research and suggest alternatives or solutions which schools might wish to explore to increase the enrollment and achievement of females, Blacks, and Hispanics in mathematics.

While the primary focus of this research effort was to examine gender and racial/ethnic group differences, considerable attitudinal data were gathered from students and school staff, providing implications which bear upon mathematics instruction for students of both genders and all racial/ethnic groups. The bulk of this summary presents the major findings of the analyses concerning each of the three study goals listed above, and provides recommendations and conclusions that result from these findings. Additionally, this summary contains the major findings that resulted from an examination of the information obtained concerning mathematics instruction for all students.

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2. The word "participation" has two meanings in this report. At the high school level it refers to the highest level of mathematics instruction the students have completed (Geometry, Algebra 2, Calculus, etc.). At the elementary and junior high/middle school levels it refers to the student's placement in the K-8 mathematics curriculum. Students are placed in different levels (above, on, or below grade level) based on their rate of progress through the countywide mathematics curriculum objectives. Students who are in the same grade level are likely to be working on different curriculum objectives, or cover the same objectives in different levels of breadth and depth, if they are in different working level groups (above, on, or below level). Thus, they are viewed as "participating" in different mathematics experiences.

Organization of the Executive Summary

Findings from this study suggest that the factors contributing to participation and performance in mathematics are quite different for females than they are for Black and Hispanic students. Differences between female and male students do not appear until late in high school, when males enroll in advanced level mathematics classes in slightly larger numbers than females, and substantially outperform females on the mathematics section of the SAT. Differences in the performance of Blacks and Hispanics compared to Whites and Asians emerge very early in elementary school, and persist throughout the educational histories of these students. Therefore, the section that presents findings related to performance and participation is divided into a discussion of findings for female students, and a separate discussion of findings for Blacks and Hispanics. Similarly, recommendations are presented separately for females and Black and Hispanic students.

The following two sections present findings concerning the first two study goals shown above: identification of points in the educational process where differences in performance and participation emerge; and identification of factors in the school, home, and society that contribute to these differences. These sections are followed by the major findings related to the instruction of students as a whole. The final section presents recommendations and conclusions.

FINDINGS: AT WHAT POINT DO DIFFERENCES APPEAR?

Findings by Gender

Participation and Performance

The data show that participation and performance in the mathematics curriculum is fairly equal for male and female students from kindergarten through the first years of high school. It is only when the mathematics requirements for graduation and college admission are satisfied that gender differences emerge, with female students leaving high school with slightly less mathematics than males.

Achievement in mathematics was measured in the elementary and junior high/middle school grades by scores on the mathematics sections of the California Achievement Tests (CAT) and performance on locally-developed and calibrated criterion-referenced mathematics tests (CRT's). At the high school level, achievement was measured by the results of administration of the CAT in eleventh grade, and the Scholastic Aptitude Test (SAT) in eleventh and twelfth grades.

Both male and female students in Montgomery County performed better on the CAT and SAT than did comparable students nationwide (see Table E-1). Male and female students in the County performed equally as well on the CAT and the CRT's. However, surprisingly large differences emerged in SAT mathematics performance, with male students significantly outperforming females. This difference in SAT mathematics performance was observed regardless of the amount and complexity of mathematics and science courses taken by the students, and despite the fact that female students received higher grades than male students in all mathematics classes (see Table E-2).

TABLE E-1

SAT Score Means by Gender for Students in the Class of 1986
Who Took the SAT in Their Junior and/or Senior Years

Year of Test	All Students	Females	Males	Male/Female Difference
Montgomery County Means				
1985: Scores for Junior Year				
Verbal	477	466	489	23
Mathematics	530	505	561	56
Total Test	1007	971	1050	79
Number of Students	3155 *	1722	1433	
1985 or 1986: Highest Score Obtained in Junior and/or Senior Year				
Verbal	479	472	486	14
Mathematics	530	506	557	51
Total Test	1009	978	1043	65
Number of Students	4185 *	2273	1912	
United States Averages for Seniors **				
1985				
Verbal	431	425	437	12
Mathematics	475	452	499	47
Total Test	906	877	936	59
1986				
Verbal	431	426	437	11
Mathematics	475	451	501	50
Total Test	906	877	938	61

* Numbers and means are slightly different from overall Montgomery County figures since only those students who were enrolled in the County during their sophomore and junior years are included in the analysis.

** Students who take the SAT as seniors tend to average about 30 points lower, overall, than do juniors and seniors combined. This should be considered when making comparisons between seniors nationwide and Montgomery County juniors or juniors and seniors. Data source: Educational Testing Service.

TABLE E-2

Highest SAT Mathematics Score Obtained in Junior and/or Senior Year
by Gender and Highest Mathematics Course Taken in High School

Highest Mathematics Course Taken	No. of <u>Students</u>		Average Score ----- Total County	Average Score ----- Female Male		Average Male/Female Difference
	Fem.	Male				
Calculus	362	399	678	659	696	37
Pre-calculus	306	284	611	588	635	47
Advanced Alg.	520	396	529	511	552	41
Alg. 2 & Trig. (accelerated)	81	63	598	575	627	52
Trigonometry	96	89	513	494	533	39
Algebra 2	384	256	460	447	480	33
Geometry	224	167	409	391	433	42

NOTE: Separate analyses were conducted controlling both mathematics and science course enrollment, and very small, random changes in average male/female differences in SAT performance were observed. Thus, for simplicity of presentation, only differences in performance within level of mathematics course enrollment are presented in this report.

Attitudes and Beliefs About Mathematics

The results of surveys of samples of students in the fourth, sixth, eighth, and twelfth grades indicate that clear differences exist among groups of students in their levels of anxiety, confidence in, liking of, and perceived utility of mathematics. Female students seemed to be somewhat less confident in their abilities in mathematics than their male counterparts. They also turned to others for help more frequently than did males. A large group of males reported that males were better in mathematics than females. Additionally, male and female students alike reported that their mothers were not as good in mathematics as their fathers were.

Students' responses by gender indicate that there was little difference between males and females in the types of colleges they hoped to go to, and the number of years of college and graduate school that they planned on completing. Career aspirations, however, were quite different for these students. Males were more likely to aspire to careers in professional occupations utilizing mathematics or the physical sciences, or managerial occupations; females were more likely to want jobs that did not emphasize mathematics, and were less likely to view themselves as future managers. This

difference in career objectives may have an influence on how much effort students are willing to take to understand the higher level mathematical concepts, and this, in turn, has an effect on SAT performance.

Supports for Mathematics in the Home and School

The data show that students' feelings about the utility of mathematics and the importance of doing well in school result in large part from parental expectations and pressures, and to a slightly lesser extent from the school environment. With the exceptions of only the very top female mathematics performers (those who finish high school mathematics with Calculus), female students receive less encouragement from the school, home, and society to pursue mathematics than male students receive.

Parents' responses to survey questions indicate that the students' mothers do not view themselves as competent in mathematics, and they communicate this message to their children. Fathers are more likely to help older children with their mathematics homework, whereas mothers are more likely to help children who are in the elementary grades and still dealing with elementary mathematical concepts. Moreover, while parents of today's students seem to be encouraging their daughters somewhat more than parents of the past did to take as much mathematics as possible, their goals for their children's future employment indicate that they still view mathematics and science careers as being primarily for men.

Principals' and counselors' responses suggest that many of them adhere to these views regarding gender and mathematics. More than 50 percent of the principals and about 60 percent of the counselors indicated that differences in the mathematics performance of males and females could be attributable to the following factors: females are not interested in mathematics, they feel they do not need mathematics for their careers, or they are not as competent in mathematics as are males. These views also appear to be reinforced by what students see in the classroom in terms of teacher competencies. In elementary school, where 90 percent of the classroom teachers are women, many teachers admit they are not comfortable teaching mathematics.

Findings by Racial/Ethnic Group

Participation and Performance

Racial/ethnic group differences in mathematics participation and performance were observed early in the students' educational history.³ Asian and White

3. It is impossible to determine without further study whether students in all racial/ethnic groups actually start elementary school with similar mathematical skills, or whether many Asian and White students come to school already advanced, with skills that their peers do not have, and which are not assessed by the tests given in the early grades. This question cannot be resolved without extensive examination of children in the preschool years, an area which was outside the scope of the current research effort. It is an area, however, in which further study would provide useful data to school systems nationwide.

students made more progress in the K-8 mathematics curriculum than did Hispanic and Black students, and the pattern was observed early in the elementary school years. While it is assumed that all students start out equally in the mathematics curriculum in kindergarten and first grade, by the end of second grade, Black and Hispanic students tend to fall below grade level in their mastery of curriculum objectives in greater numbers than do Asian and White students, and Asian and White students begin to move ahead or accelerate in the curriculum in greater numbers than do Hispanic and Black students.

The evidence suggests that once a student falls below the standard level of performance in the curriculum for his/her grade level, he/she is not likely to ever again catch up to that grade level standard of performance. And, with each year in school, additional students either fall behind or move ahead, producing a difference in the progress of Black and Hispanic compared to Asian and White students that gets wider each successive year. Exhibits E-1, E-2, and E-3 illustrate the cumulative effect of differences in progress for each racial/ethnic group throughout the elementary school years.

The result of the cumulative differences between the groups is that, by the end of the elementary school years, as critical decisions are being made concerning class placement for seventh grade mathematics, as many as one-third to one-half of the Hispanic and Black students have fallen so far behind in the mathematics curriculum that there is little or no possibility of their being placed in a level of seventh grade mathematics that would allow them to be ready to take Algebra 1 in eighth or ninth grade.⁴ It is no great surprise, then, to find that at the high school level, the most advanced mathematics courses (Pre-calculus and Calculus) are dominated by Asian and White students.

The pattern of performance on mathematics achievement measures by racial/ethnic group is comparable to the pattern observed for student progress and participation in the curriculum. Although students in each racial/ethnic group in Montgomery County performed better, on the average, than did comparable students nationwide on the standardized achievement measures, Asian and White students in the County outperformed Black and Hispanic students (see Table E-3). This pattern, which is comparable to what is observed nationally for the four racial/ethnic groups, was found as early as the third grade, the first time students are tested on the CAT, and continued through eleventh grade. Performance differences on the SAT were also large. Not only did Asian and White students outperform Hispanic and Black students on the test, but the proportions of each group who opted to take the test differed markedly as well: Asian and White students took the SAT in the largest numbers.

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4. Students who progress normally through the mathematics curriculum are expected to take Algebra 1 in the ninth grade, to complete mathematics courses at least through Algebra 2 or Advanced Algebra in high school. Accelerated students take Algebra 1 in the eighth grade, and can take Calculus if they remain in the accelerated mathematics courses throughout high school. Sixty percent of the Black students and 52 percent of the Hispanic students in this study left high school with Geometry, Algebra 1, or lower mathematics courses as the last course they completed. Figures for White and Asian students were 32 and 13 percent.

EXHIBIT E-1

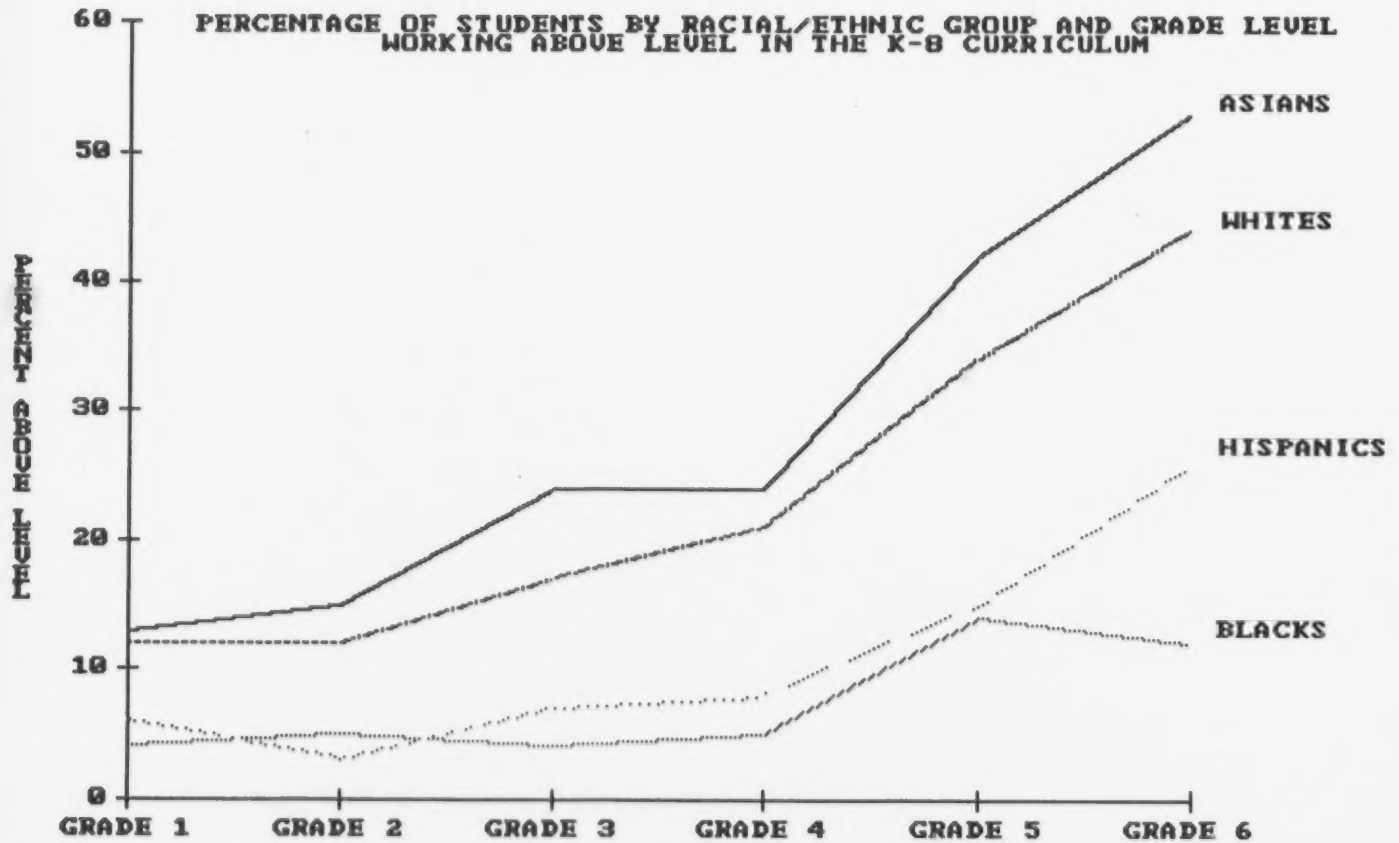


EXHIBIT E-2

PERCENTAGE OF STUDENTS BY RACIAL/ETHNIC GROUP AND GRADE LEVEL
WORKING ON GRADE LEVEL IN THE K-8 CURRICULUM

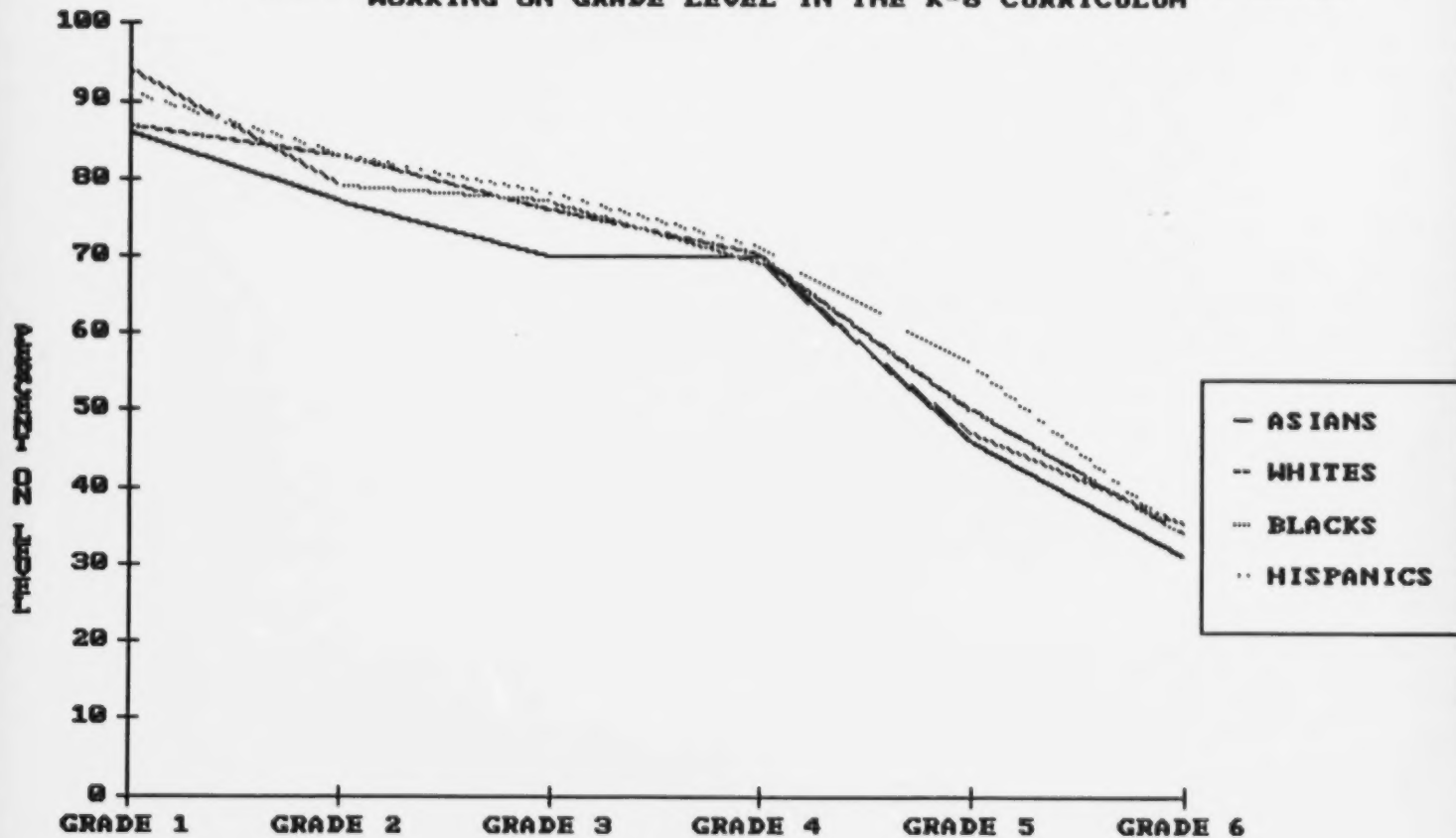


EXHIBIT E-3

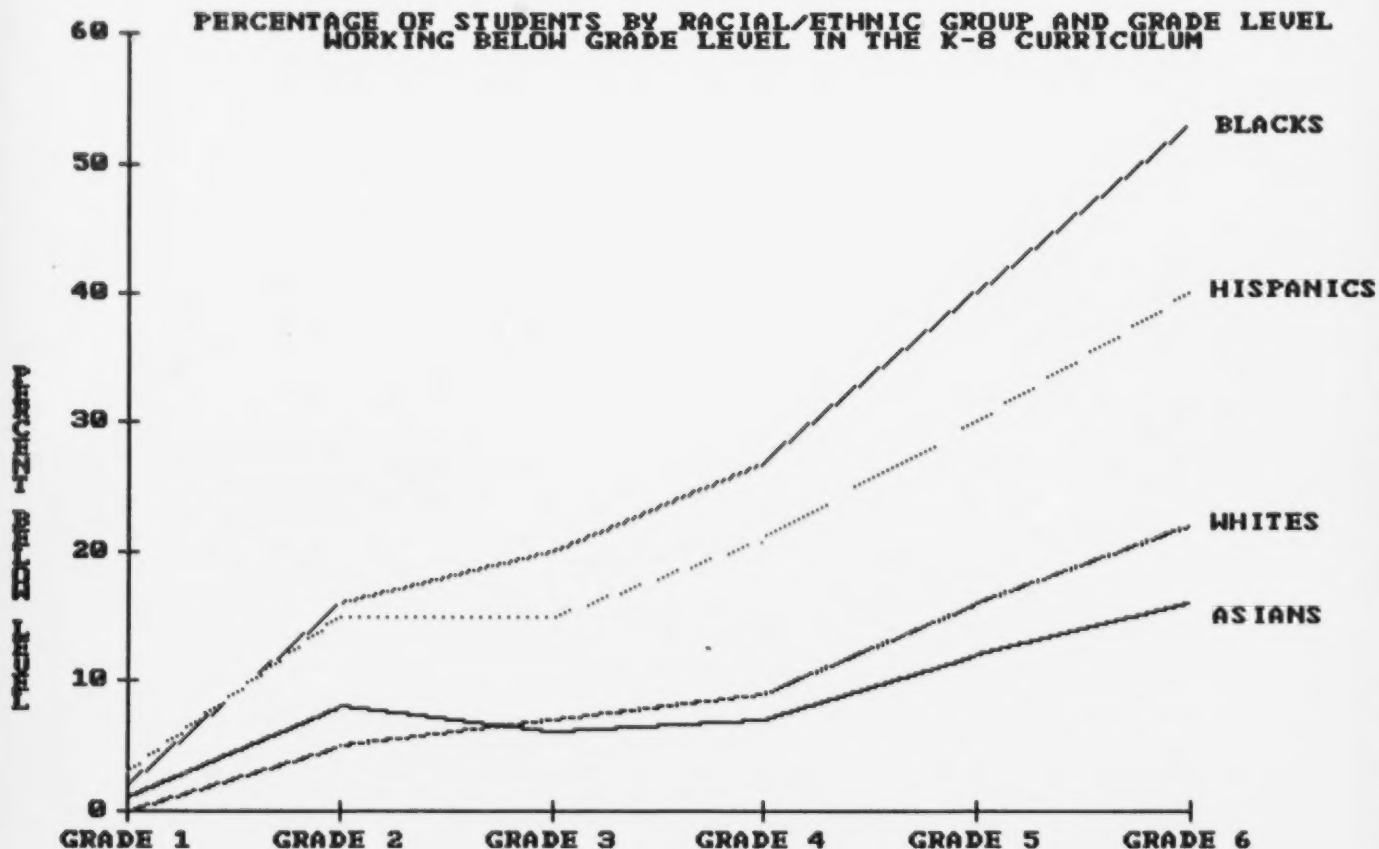


TABLE E-3

Stanine Scores of Students in the Class of 1986 on the Eleventh Grade CAT
Mathematics Section by Racial/Ethnic Group

Stanine	% of Students Nationally in Each Stanine	% of All Asians in MCPS	% of All Whites in MCPS	% of All Blacks in MCPS	% of All Hispanics in MCPS
9 (highest)	4	37	20	4	11
8	7	12	12	3	6
7	12	15	19	11	10
6	17	16	24	21	19
5	20	11	15	23	25
4	17	7	8	25	17
3	12	2	2	11	8
2	7	0 *	0 *	1	2
1	4	0 *	0 *	1	1
Number of Students		499	5,313	857	280

* Percentage is less than half of one percent.

Further, while performance on standardized achievement tests of students in all gender and racial/ethnic groups appears to be related to level of participation in the mathematics curriculum, Black students, regardless of level of participation in the curriculum, consistently scored lower on the standardized tests than did their classmates who were in the other racial/ethnic groups. Even at the highest levels of participation (students enrolled in Algebra 2, Trigonometry, Advanced Algebra, Pre-calculus, or Calculus at the high school level), Black students did not perform on standardized tests at the same level as students from the other racial/ethnic groups (see Table E-4).

Attitudes and Beliefs About Mathematics

Few racial/ethnic group differences in attitudes toward mathematics were observed; the majority of the students and parents felt mathematics was necessary, and generally, students liked mathematics. High achieving Black students expressed a greater commitment to mathematics compared to what

TABLE E-4

Eleventh Grade CAT Performance of Students in the Class of 1986:
by Highest Mathematics Course Taken in High School and Racial/Ethnic Group

Highest Mathematics Course Taken and Racial/Ethnic Group			High *			Middle	Low
			Sta. 9	8	7	Stanine 4-6	Stanine 1-3
Calculus	Asian	155	79 %	14 %	7 %	1 %	0 %
	White	670	78	17	5	0 **	0
	Black	24	67	17	17	0	0
	Hispanic	16	75	19	6	0	0
Pre-calculus	Asian	93	41	18	33	8	0
	White	568	46	27	22	6	0
	Black	36	22	33	28	17	0
	Hispanic	23	52	30	13	4	0
Advanced Algebra	Asian	76	12	18	22	47	0
	White	923	12	19	41	28	0
	Black	99	4	3	41	52	0
	Hispanic	31	16	7	32	45	0
Algebra 2 with Trig.	Asian	16	31	19	13	38	0
	White	155	43	27	25	6	0
	Black	6	17	0	67	17	0
	Hispanic	7	29	14	43	14	0
Trigonometry	Asian	25	8	12	8	72	0
	White	189	13	21	32	34	0
	Black	26	8	0	35	58	0
	Hispanic	8	0	13	38	50	0
Algebra 2	Asian	48	6	4	17	71	2
	White	760	4	8	29	59	0 **
	Black	103	1	2	15	81	2
	Hispanic	29	0	7	17	76	0
Geometry	Asian	28	0	4	7	89	0
	White	564	1	4	13	82	0 **
	Black	121	0	2	4	93	2
	Hispanic	34	0	0	6	94	0
Algebra 1	Asian	22	0	0	0	82	18
	White	381	1	1	5	91	4
	Black	108	0	0	1	88	10
	Hispanic	30	0	0	0	83	17

* Stanines 9, 8, and 7 are shown separately to illustrate the differences among the racial/ethnic groups.

** Percentage is less than half of one percent.

students in other racial/ethnic groups showed. They expressed a desire to do well in mathematics so they could move on to good colleges and professional careers. This commitment was reinforced by their parents' feelings about the importance of mathematics.

Supports for Mathematics in the Home and School

Parents in general felt that mathematics was important in their children's futures. Parents of Black students were the most vocal in expressing this belief. They were significantly more likely to feel that all students needed as much mathematics as possible, and that their children should continue in mathematics even if their chances of receiving a grade of A or B were unlikely. Parents of Black students were also most vocal in expressing their willingness to interact with their children's teachers or other school staff if they felt their children were having problems in school.

Responses from students also indicate that Black students perceive differences in how they and other students are treated in class. High achieving Black students reported that they had to prove themselves to the teacher each time they entered a new mathematics class. They felt that teachers who had Black students in their honors or accelerated classes saw them as tokens, or as inferior to White students in the class. Black students felt a sense of isolation in these classes, especially in schools in which there might be only one or two Black students in each honors class.

These feelings articulated by high performing Black students were substantiated by teachers' assessments of students' performance in class. While students in the four racial/ethnic groups had fairly similar mathematics grades in early elementary school, in the later elementary and secondary years Black students consistently had the worst grades, even if they were working at accelerated levels in the curriculum. Hispanic students' grades were just slightly higher than those of Blacks. Whites and Asians had the best grades.

Survey responses indicate that many counselors and principals feel educational problems begin in the home. Sixty-seven percent of the elementary and junior high/middle school principals surveyed and 79 percent of the junior high/middle and high school counselors surveyed felt that the differences in achievement and performance in mathematics that are observed among different racial/ethnic groups stemmed from home variables. They viewed Asian and White students as coming from homes in which education is supported and participation in mathematics is encouraged. They cited economic factors and fragmentation of families as reasons for the lack of motivation and interest in mathematics they felt was dominant among Hispanic and Black students. While many school staffers felt that school systems needed to work hard to overcome these obstacles, some felt that these problems emanated from society and there was nothing that the schools could do until society changed.

Lastly, the data concerning personal characteristics of teachers indicate that there are few potential mentors or role models among the teaching staff for the three minority groups: Asians, Hispanics, and Blacks. Among counselors, there is also underrepresentation of Asians and Hispanics. Montgomery County is well aware of this problem, however, and is expending considerable effort and resources to recruit minority staff.

Several interpretations are possible for the discrepancy between the attitudes and beliefs of Black students and their parents toward education in general and mathematics in particular, and the degree of reinforcement these students receive through their test scores, class grades, and beliefs expressed by school staff. A cursory look at the data might suggest that there is a bias toward Black students that is expressed through these factors. However, it is also possible that the school system, in an effort to make advanced level classes more available to minority students, has placed some Black youngsters in classes above the level that their "paper credentials" would indicate to be appropriate. We cannot determine the real reason without more intensive data collection efforts than were possible in this study. However, if the latter interpretation were to be borne out, the fact that Black students can successfully complete these advanced level classes despite their lower test scores and report card grades would support the continuation of the practice of encouraging them to participate in higher level classes.

Overall, our findings suggest a different pattern of participation, performance, and rewards for performance of Black and Hispanic students compared to Asian and White students, and they corroborate the results of other research efforts. Further, the views of school staff and Black parents appear to differ regarding perceived parental support of their children's persistence in accelerated mathematics classes. Greater efforts to promote understanding between the school and the home would help in overcoming these differences.

FINDINGS: WHAT FACTORS CONTRIBUTE TO DIFFERENTIAL PERFORMANCE AND PARTICIPATION?

The findings presented above indicate that the pattern of participation and performance in mathematics differs markedly for females compared to Black and Hispanic students. While males and females participate and perform in mathematics at almost equal levels until the middle of their high school years, differences in the participation and performance of Black and Hispanic students compared to White and Asian students occur quite early in elementary school.

Results of statistical analyses of the available data suggest that attitudes and beliefs about mathematics, classroom participation, and test performance are highly related to each other. Generally, students who performed at higher levels in the curriculum felt less anxious, liked mathematics better, and saw a greater use for mathematics than did students who performed at lower levels. They also had a greater variety of strategies they could use to attack mathematics problems. Regardless of gender or racial/ethnic group membership, the more favorably students viewed the subject of mathematics, and themselves as competent mathematics performers, the more likely they were to persist in higher levels of the mathematics curriculum. Thus, attitudes about mathematics play an important part in shaping students' participation and performance in the mathematics curriculum.

Results of regression analyses show that participation and performance in the mathematics curriculum is strongly related to students' performance on achievement measures such as the CAT and SAT. Between two-thirds and three-fourths of the variation in how students perform on the achievement measures

can be directly related to how well they have performed or to what extent they have participated in the mathematics curriculum. Moreover, doing well (getting good grades) in the curriculum enhances this relationship.

Those students who performed at accelerated levels in the curriculum produced the highest average scores on the standardized tests. Those students who performed at average levels in the curriculum performed better on the standardized tests than students who performed at lower levels in the curriculum. While it is conceivable that the relationship between performance in the curriculum and test performance is circular, with those who do well in class doing well on tests and thus being spurred on to continue to do well in class, etc., it seems likely that increasing students' opportunities to attain more curriculum objectives might have substantial payoffs in test performance down the road.

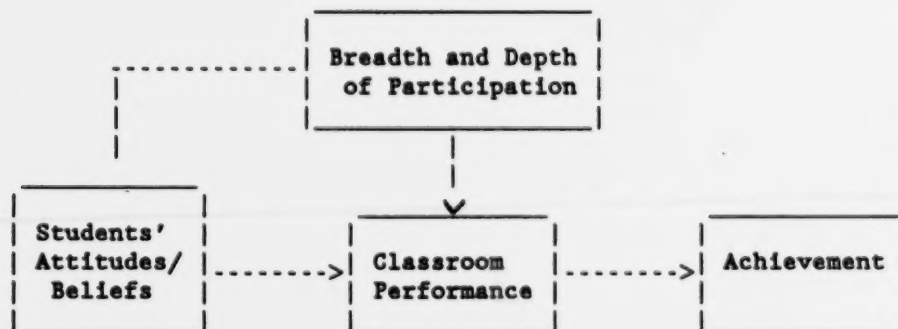
The fact that differences in the participation and performance of many Black and Hispanic students compared to Asians and Whites occur very early in the school years suggests that Black and Hispanic students do not cover the same breadth and depth in the curriculum as do Asian and White students. Thus, whereas for students, overall, a model linking attitudes, performance in the curriculum, and achievement might be formulated as follows:

attitudes influence students' ability or willingness to perform in the curriculum, and performance and participation in the curriculum ultimately influence students' mathematics achievement,

the impact of the breadth and depth of participation in the curriculum must be considered when examining the ultimate performance and achievement of Black and Hispanic students. Thus, the model shown in Exhibit E-4 is suggested.

EXHIBIT E-4

Proposed Model of Factors Related to Mathematics Achievement



FINDINGS RELATED TO THE MATHEMATICS INSTRUCTION OF ALL STUDENTS

Students' Attitudes About Mathematics

Findings regarding attitudes and performance for all students mirror those reported above by gender and racial/ethnic group. In general, students who performed or participated at higher levels in the mathematics curriculum than their peers felt less anxious, liked mathematics better, and saw a greater use for mathematics than did students who performed at lower levels. They also had a greater variety of strategies they could use to attack mathematics problems. The findings presented in Volume I suggest that the more favorably students viewed the subject of mathematics, and themselves as competent mathematics performers, the more likely they were to persist in higher levels of the mathematics curriculum. The data reported in Volume II corroborate these findings.

Students' Feelings of Support in School and at Home

The Home

Comments from students isolate one variable above all others that they feel separates students who are good in mathematics or who pursue mathematics from those who are not good/do not pursue it. Students in the accelerated mathematics classes pointed to their parents as the primary force behind their interest in mathematics. They talked about the encouragement, interest in, and exposure to mathematics that their parents provided to them. These students also indicated that their parents expected them to take a lot of mathematics and do well.

Students in lower level mathematics classes did not seem to receive the same level of parental support for academics in general, let alone mathematics in particular as did those in accelerated classes. Comments from these students suggest that economic factors, i.e., whether they have to work after school, or whether their parents work more than one job, affects how much parental encouragement they receive. Moreover, the data suggest that, for about one-third to one-half of the students in secondary school, there is no one in the home who is capable of helping them with their mathematics homework.

The School

Junior high/middle and senior high school students were asked to reflect on their mathematics instruction, and the importance of mathematics teachers to them. The data suggest that students' feelings about their teachers can influence how much effort they are willing to put into the class. They also suggest that, in the absence of support from the home, teachers can play a critical role in shaping students' interest in mathematics. Over half the students in both groups felt that their mathematics teachers were good teachers. There was a tendency for the better mathematics students to feel more positively about their teachers and the poorer students to feel more negatively. However, there were many students working at lower levels in the mathematics curriculum who spoke favorably of mathematics teachers, and many students working at accelerated levels who made negative comments about mathematics teachers.

Feelings about their teachers, either positive or negative, ran very strong among the students. Students were very explicit about the characteristics of good (effective) and ineffective teachers. Students who were working at lower levels in the curriculum were more likely to report that they had had ineffective mathematics teachers than were students who participated in accelerated mathematics classes or groups.

According to the students, effective teachers took time with them, answered all questions patiently, nurtured students' feelings of confidence and competence, and instilled in students a sense of the importance of mathematics. Ineffective teachers, on the other hand, were perceived as being insensitive to students, particularly slower students. They were regarded by the students as more concerned with getting through the material than with making sure that all students understood. Ineffective teachers were seen as nasty, sarcastic, punitive, and not liking students. Moreover, these teachers were seen as doing nothing to make class interesting, and students often felt these teachers did not want to be in the classroom teaching them.

Teachers' Perceptions of Students

Accelerated students were viewed by teachers as significantly more capable and prepared for class than other students. They were viewed by their teachers as more studious, better behaved, and capable of going further in mathematics and in school in general than were students in other mathematics classes. Commensurate with their opinions about the students, teachers expected more of the accelerated students than they did of other students in their classes.

The data suggest that students who work at advanced or accelerated levels in the mathematics curriculum experience a mathematics education that is different in many ways from that provided to students who work below grade level in the curriculum. Students working above level in the curriculum are taught more complex mathematical concepts, and they are expected to produce more complete work and think at a higher level than their fellow students.

Instructional Opportunities

Montgomery County policy on the grading and reporting of student progress⁵ states that:

Students are expected to maintain at least a B average in honors level work ... When a student receives a grade of C ... he/she should be counseled about ways to improve. A student who receives a grade of D or E (failure) will be removed from honors level work in the designated course.

Indeed this policy appears to have had a substantial impact on students' opportunities in mathematics. In accordance with this policy, teachers,

5. Montgomery County Public Schools' Administrative Regulation IKA-RA.

counselors, and principals indicate that accelerated mathematics is perceived by school staff as being appropriate content for only the most advanced or capable students. Teachers, guidance counselors, and school principals all indicated that only those students who are likely to receive A's or B's in the next mathematics course are typically recommended for accelerated or honors classes. This judgment is based on the student's performance in the prior mathematics class, and teacher recommendation. Thus, teachers have a large say in the future mathematics path of their students.

Opportunity to learn the mathematics content is significantly affected by the level of mathematics class into which the student is placed. Elementary school teachers reported that they have different expectations for students who are working above grade level in the curriculum than they do for students working on grade level. Similarly, they have different expectations for those working on grade level than they do for those working below grade level. Secondary school teachers indicated that they have different expectations for students who are in college preparatory mathematics classes than they do for general mathematics students.

Teachers expect students who are working at accelerated levels in the curriculum to be able to analyze, synthesize, and apply classroom knowledge to new situations. Students working below level in the curriculum are primarily exposed to rote learning, drill, and the simplest of mathematical problems and examples. Thus, students who are moved into lower mathematics classes or groups will likely fall behind those students who remain in the higher group, simply because of the difference in instruction they receive. This results in a situation whereby few students can move back up to a higher level group in mathematics without some assistance.

The study findings indicate that many students are sufficiently concerned about the potential impact on their grade point averages that participation in advanced level mathematics classes may have that they do not take these classes even when eligible to do so. Female, Black, and Hispanic students are more likely not to take these classes for fear of receiving lower grades than they would like to receive or are used to receiving. These findings suggest that these students and their parents need to be made more aware of the importance of accelerated mathematics courses, not only for career purposes, but also for the variety and depth of instruction to which they would be exposed.

POLICY IMPLICATIONS AND RECOMMENDATIONS

The findings from this study indicate that students in Montgomery County participate and achieve in mathematics at levels that are better than national averages. However, the study identified several areas in which MCPS students of different genders and/or racial/ethnic groups participated or achieved differently from each other.

Since students in Montgomery County receive educational services that are equal to or better than those provided elsewhere in the nation, we feel that these findings are especially significant. The fact that we have extensive data bases of student information, as well as procedures for monitoring the progress of students in the K-8 mathematics curriculum, places us ahead of most school districts in the country in terms of what we can provide to our

students. Given these supports, the finding that differences exist here suggests that the problems with which we are dealing are deep-seated and difficult to address. Further, given the benefits of the Montgomery County education, we feel it likely that the status of female, Black, and Hispanic students in mathematics in school districts across the country might well be far worse than what we have observed here. Indeed, research studies conducted elsewhere suggest that these problems are widespread.

Based on our study findings a number of viable strategies emerge as ways of coping with these problem areas. The following sections contain recommendations that school systems can use to improve mathematics instruction and students' experiences in mathematics.

Participation and Performance by Gender

Attitudes and Beliefs

While differences in participation and performance in mathematics by gender do not emerge until the last year or two in high school, the findings from this study indicate that differences in attitudes and beliefs about mathematics start much earlier. The study has demonstrated the relationship between attitudes and beliefs and participation and performance in mathematics. Thus, these suggestions are intended to address the differences in attitudes and beliefs that are observed.

- o School systems should look for ways to communicate more strongly to female students and their parents the importance of mathematics for all students, and the viability of technical careers for females as well as males. And, since students' early attitudes and beliefs are largely developed at home, parent education should be a major focus of this effort.
- o School systems need to launch public relations campaigns to change the image of mathematics. Mathematics should be thought of as exciting, challenging, and desirable as opposed to necessary or a means to an end. Particularly at the junior/high middle school level, where students seem to be influenced most heavily by peer pressures, an effort should be made to try to staff mathematics classrooms with exciting, dynamic, and charismatic teachers, and to present material in a way that broadens students' understanding of the importance and relevance that mathematics has to a multitude of disciplines and careers.
- o If school systems truly want as many students as possible to enroll in more advanced mathematics courses, the notion that honors classes should be taken only if the student can be well assured of a grade of A or B should be reconsidered. It is likely that many students, particularly females, are reluctant to enroll in classes in which the prospect of a low grade carries such a stigma. Also, for some students, mathematics knowledge appears to be acquired in fits and spurts, with the student appearing to be stuck in a rut for a time, and then, almost overnight, having everything fall into place. Maintaining narrow performance standards could result in these students being unnecessarily eliminated from higher level mathematics classes. If anything, students who demonstrate that they are willing to aspire to higher standards by

enrolling in these advanced level classes should be awarded some tangible or psychological reward for risking their good grade-point-averages in this way. Thus, the data suggest that the practice of weighted grades for honors or advanced level classes makes a lot of sense, and we suggest that school systems consider adopting this practice if they do not already do so. Additionally, school systems that compute weighted grades for honors level classes in which the students receive grades of A or B should consider expanding this policy to grades of A, B, or C.

Performance on the SAT

The solutions to the differential SAT mathematics performance by gender are not as readily apparent as are some of the other solutions suggested by this study. While we have moved somewhat closer than other research efforts have in examining this issue, large differences in performance still exist for which there are no definitive explanations. Further research is needed regarding the differential performance of females and males on the SAT. The following activities are recommended as starting points for this research:

- o Intensive case studies of statistical outliers, e.g., those females who perform exceptionally well on the SAT mathematics section, should be conducted. Use of case studies rather than survey techniques would allow for greater in-depth examination of the attitudes, beliefs, and home and school factors that have surfaced in the current study as being important variables to consider.
- o It would be useful and interesting to compare the performance of male and female students within the same school system on each item of the SAT mathematics section. Those items (if any) that appear to discriminate between females and males could be examined in relationship to course enrollments of the students and SAT verbal performance. Whereas ETS has conducted analyses of SAT performance and course enrollment data across various school systems where courses of the same name could differ substantially in content, Montgomery County has the benefit of its extensive historical computer data files for large groups of students who have taken the same course of study. Comparison of SAT performance for these students might yield some new information that was hidden in the analyses that were conducted by ETS across many school districts. Inclusion of SAT verbal performance in these analyses would enable us to examine whether differences that emerge are test-specific or mathematics-specific.

Progress and Performance of Black and Hispanic Students in the K-8 Mathematics Curriculum

The data from this study indicate that differences in student progress through the elementary school mathematics curriculum emerge as early as the first and second grade. Black and Hispanic students tend to fall behind in greater numbers than White and Asian students, and they do not accelerate above level in as great numbers either.

Suggestions for Remediation and Enrichment Programs

School systems must take extraordinary steps to ensure that students who fall below grade level in their progress through the mathematics curriculum in the early grades have every opportunity to be brought back up to grade level as soon as possible. The following steps could be taken to address this need:

- o Summer school programs could be designed and put into place for students in kindergarten, first, and second grades who are in danger of or who have already fallen below grade level in mathematics, or who did not come to school with the appropriate mathematics readiness skills. Parents must be made aware of why participation in these programs is essential for their children.
- o After school programs in mathematics could be established for students in grades 3-6 who need to be brought up to grade level in mathematics or who are in immediate danger of falling below level. Students in these grades could participate in both after school and summer school programs if needed. In school systems in which large numbers of students are bussed to school, transportation should be provided for the after school programs so that those students most in need of the services will be able to participate.
- o School systems should consider establishing mathematics resource teacher or mathematics specialist positions in elementary schools with large numbers of students in the early grades who need remediation in mathematics. These teachers could work with small groups of students, and also serve as resource people to the classroom teachers who are in need of assistance in teaching mathematics.
- o School systems should consider establishing after-school and/or summer school enrichment programs in mathematics especially geared for elementary school students who have the potential to be moved from on-level to above-level performance with a little assistance. Parents of Black and Hispanic students should be contacted directly by school staff and strongly encouraged to enroll their children in these programs. Transportation should be provided as part of this program.

Parental Support

We feel that school systems, parents, and other community members could work more closely together to meet the needs of the students. We suggest the following:

- o School systems should develop or adopt programs which foster support of the educational goals at home. These programs could include workshops for parents that give them the skills necessary to help their children with homework assignments. The workshops could be conducted either in group settings, or recorded on video tape so the parents could use them at home. MCPS currently uses parent awareness workshops for this purpose. The County has also endeavored to adopt and evaluate the success of programs developed outside the school system that foster parent involvement. The Family Math program, developed at the University of

California, Berkeley is an after school program designed to provide parents with hands-on experience working with their children in mathematics at home. It is currently being tried in several schools in Montgomery County. PIBS (Parent Involvement in Basic Skills) is another program supported by the school system to involve parents in their children's work. Additionally, MCPS conducts a homework hotline on local Cable TV. Responses to this program indicate that it may be an effective means of reaching students and parents in the home.

- o A lending library of video tapes could be developed to be used by students and parents to learn essential mathematical concepts. These tapes could be made available in school and public libraries as well as in housing and recreation centers and day care centers.
- o School systems could explore ways of obtaining cooperation from recreation centers and day care centers to provide tutoring services to students. The tutoring sessions could take place in the recreation centers and day care centers, and could be conducted by trained high school students or adult volunteers. MCPS recruits adult tutors through its connections with businesses and industry.

Teacher Training

The data indicate that elementary school teachers may not have the requisite training to be as comfortable teaching mathematics as they are teaching other subjects. Thus, students may not be receiving as complete instruction in mathematics as they do in reading, for example, in the early years. Or, teachers may not be as aware of the variety of ways mathematical concepts can be introduced to students who have different learning modalities. The following suggestions address these needs:

- o School systems need to explore ways of retraining their pool of elementary school teachers. Montgomery County's Department of Quality Integrated Education, in cooperation with American University, sponsors a program in several County elementary schools which retrains classroom teachers in effective strategies for teaching science and mathematics. Montgomery County staff who have been involved in this program feel it has substantial benefits. The success of this program could be evaluated for potential dissemination to other school systems. Similar positive results have been obtained in elementary teacher training programs developed and conducted by MCPS, which were supported by Title II EESA funds.
- o School systems or the NSF could consider developing a set of video tapes that could be used to train teachers in the most critical mathematical concepts or strategies that are deemed to be lacking. Teachers could borrow these tapes for self-instruction as needed.
- o Montgomery County has retrained elementary school teachers who were interested in teaching junior high/middle school mathematics. Those who were involved in this effort felt it was an effective way to acquire staff in areas of great need. School systems could consider retraining some junior high/middle school mathematics teachers who would be interested in teaching mathematics in the elementary school.

- o School systems should consider in-service training for junior and senior high school teachers in career awareness activities, and ways they can be more nurturing in the classroom and more sensitive to racial and sex role stereotypes.

Participation and Performance of Black and Hispanic Students in the Secondary School Curriculum

Large differences in participation and performance in the secondary school curriculum were observed by racial/ethnic group. A good part of the differences in participation that are observed at the secondary level are most likely a result of options being closed due to student differences in progress through the K-8 curriculum. Nevertheless, the study data suggest that many students leave the mathematics curriculum early or do not participate in the most advanced levels in the curriculum for other reasons. The following suggestions are aimed at keeping these students, for whom options have not been closed as a result of their progress in the K-8 curriculum, involved in the secondary school mathematics curriculum at the highest levels possible:

- o School systems need to communicate more fully to students and their parents the importance of taking as much mathematics as possible in high school. Many parents are unaware of the importance to their children of staying in the mathematics curriculum after high school graduation requirements have been met. Responses from Black and Hispanic parents on the study surveys indicate that they would support the school system in its efforts to increase student enrollment in accelerated mathematics classes if they were made aware of the importance of these classes to their children's futures. School systems could use the resources of prominent community members from the same racial/ethnic group to assist in this communication process.
- o Black and Hispanic parents need to be made more aware of the importance of SAT performance in their children's college plans. Parents should be instructed in the options available to students in preparing for the test, and the potential benefit to students of taking the test early in their high school years for practice purposes.

Mathematics Instruction of All Students

The findings presented above that discuss the mathematics instruction of all students suggest several areas in which changes could be made to the mathematics curriculum and how mathematics is presented in the classroom.

- o Student responses suggest that those in the lower performing classes are suffering not only from an inability or lack of confidence in mathematics, but also from the perception, accurate or not, that their teachers do not want to be bothered by their "stupid" questions. School systems need to provide alternative classroom environments that are more encouraging and nurturing for these students.
- o Students in the lower performing classes indicate that they receive the same or similar instruction year after year in repetitive content.

Teachers' responses suggest that this perception is accurate. It is recommended that school systems explore alternative methods and content of instruction for these students, so that these students can experience some of the fun aspects of mathematics.

- o The data suggest that some students would be interested in taking mathematics beyond the level of Algebra 2 or Advanced Algebra if they had course options other than the traditional theoretically based Pre-calculus and Calculus courses. The possibility of developing an alternative course offering for these students might be considered by NSF and school systems. Such a course might include many of the Pre-calculus and Calculus concepts in an applied, rather than theoretical setting. The use of microcomputers to support this instruction also might be considered. MCPS has received some federal money to study the development of such a curriculum.
- o The findings indicate that students in the accelerated mathematics classes receive instruction that includes considerably more analysis, synthesis, and other higher order thinking processes than the content presented in average or below level mathematics classes. Similarly, students in the average levels of instruction participate in higher level skills than do those in the below level classes. Thus, once placed in a lower level group, it is difficult for the student to move to a higher group. These findings suggest that caution be taken by teachers and principals before students are moved to lower groups, and that movement to lower groups be considered only after a variety of measures have been attempted to keep the student on the same level as his/her classmates or groupmates.

CONCLUSION

The findings presented in both volumes of this report show that, in many areas of mathematics instruction, MCPS is making great strides toward meeting the needs of its students. However, as is true in any large school system, there still remain areas in which improvement could be made. The findings also raise concerns which are generalizable to instruction and learning of mathematics nationwide.

It appears that the best way to be successful in mathematics is to have succeeded in mathematics in the past. Once a student experiences failure in mathematics or falls behind in completing the instructional objectives at his/her grade level, it is much more difficult to catch up. The data from this study show that this is more of a problem for Blacks and Hispanics than for Whites and Asians.

Montgomery County has been addressing the specific needs of its female, Black, and Hispanic students for more than a decade, and has expended substantial financial and staff resources on solutions to the problems. The finding that improvement is still needed only serves to illustrate the complexity of the issues with which we are dealing, and suggests what must be a bleak picture for these groups of students in school systems which have not yet fully focused on the problems.

FACT SHEET

PARTICIPATION AND PERFORMANCE OF WOMEN AND MINORITIES IN MATHEMATICS

What was the purpose of the study?

This study explored those factors which were believed to contribute to differential participation and performance in mathematics of students in different gender and racial/ethnic groups. Participation and performance were examined within the context of the elementary, junior high/middle, and high school environments. The overall goals of the study were threefold:

- o to identify at what points, if any, in the educational process differences appear in the mathematics participation and performance of females compared to males, and Blacks and Hispanics compared to Asians and Whites, and to describe these differences
- o to identify the factors in the school, home, and society that contribute to the differential mathematics participation of female, Black, and Hispanic students at the elementary, junior high/middle and senior high school levels
- o to provide, where possible, the policy implications of the research and suggest alternatives or solutions which schools might wish to explore to increase the enrollment and achievement of females, Blacks, and Hispanics in mathematics.

What data were gathered and/or utilized in the study?

The following performance and participation data were gathered for this study:

- o progress of students in the K-8 mathematics curriculum (ISM) - about 3,000 students per grade level for grades 1-6, and 2,000 students per grade level for grades 7 and 8 (computerized records were available for students in schools with computer-assisted assessment)
- o student enrollment in high school mathematics courses - more than 6,000 high school seniors
- o students' report card grades in mathematics - more than 6,000 high school seniors, and approximately 300 students each from grades 4, 6, and 8
- o performance on the County-developed criterion-referenced tests in mathematics (CRT's) - approximately 6,000 students per grade level, grades 3-8
- o performance on the mathematics subtests of the California Achievement Tests (CAT) - approximately 6,000 students per grade level, grades 3, 5, 8, and 11
- o performance on the mathematics and verbal sections of the Scholastic Aptitude Test (SAT) - approximately 4,000 students

Students had to be enrolled in MCPS for at least two years prior to the study to be included in the analyses.

Information concerning attitudes and beliefs about mathematics was collected from the following sources:

- o student responses to questionnaire items designed to measure such concepts as confidence in mathematics, interest in mathematics, perceptions of the utility of mathematics, and postsecondary aspirations - approximately 300 students each from grades 4, 6, and 8, and more than 500 students in grade 12
- o information gathered through focus group discussions with students in grades 8, 11, and 12 (small group guided discussions with same-gender, same-racial/ethnic group, and same-achievement level students) to obtain information on the factors that influenced their participation in mathematics and their success or lack of success in mathematics - 16 groups of approximately 10 students each
- o parent responses to questionnaire items concerning their attitudes and beliefs about mathematics, and their perceptions of and educational and career goals for their children - between 100 and 200 parents of students in each of the student samples above for grades 4, 6, 8, and more than 200 parents of 12th graders
- o surveys of mathematics teachers of students in the samples regarding their perceptions of the sample students and their attitudes and beliefs about mathematics instruction - more than 80 teachers each in grades 4 and 6, approximately 40 for grade 8, and more than 160 for grade 12
- o surveys of a sample of junior high/middle and high school guidance counselors of sample students, regarding their attitudes and beliefs about mathematics - 82 counselors
- o surveys of elementary and junior high/middle school principals of students in the samples, regarding their attitudes and beliefs about mathematics - 48 principals

How were participants selected for each sample?

Students were selected from three levels of performance in the K-8 mathematics curriculum (those working above, on, or below grade level) and from three levels of performance on the SAT mathematics section (650 and above, 520-640, and below 520). The samples were balanced as evenly as possible, so there would be similar numbers of Asians, Blacks, Hispanics, and Whites, as well as males and females in each performance level. Students included in the study were enrolled in MCPS for a minimum of two years prior to data collection.

Parents, teachers, and counselors of half the students in the student samples were selected at random. Principals of all elementary and junior high/middle schools that had students in the study samples were interviewed.